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(54) **Thermoplastic elastomer blends**

(57) Thermoplastic elastomer blends of low hardness comprise a polynorbornene and polyolefin resin, the polynorbornene having been cured during blending by the addition to the blend of a curative. The compositions may also comprise selectively hydrogenated styrene/diene block copolymers.

GB 2 162 526 A

## SPECIFICATION

### Thermoplastic elastomer blends

5 This invention relates to thermoplastic elastomer blends. 5

It is known to produce thermoplastic elastomer blends by dynamic vulcanisation of a blend of EPDM rubber and polyolefin resin so that the rubber is substantially fully cured. Such thermoplastic elastomers have very useful properties and can advantageously be used in place of conventional thermosetting rubbers. However, it has been found difficult to produce by that process a thermoplastic elastomer of low hardness for example having a Shore A hardness less than 70. 10

According to the present invention there is provided a thermoplastic elastomer comprising a blend of a polynorbornene and a polyolefin resin, the polynorbornene being cured during blending by the addition of a curative.

15 The invention also provides a process for producing a thermoplastic elastomer comprising mechanically blending polynorbornene polymer and a polyolefin resin, and during said blending heating the mixture, and adding a curative to the mixture when said mixture is at least substantially molten and continuing said mechanical blending until the polynorbornene phase in said blend is substantially cured. 15

20 The essential constituents of the thermoplastic elastomer blend are polynorbornene and a polyolefin resin. 20

The polynorbornene is preferably produced by polymerising norbornene which is itself produced from ethylene and cyclopentadiene by Diels-Alder Synthesis. The polynorbornene is preferably an amorphous polymer in powder form, having a molecular weight above 2,000,000. A commercially available polynorbornene which can be used in the invention is marketed as "Norsorex" has a real density of 0.96 and a second order vitreous transition temperature of 35°C. 25

The polyolefin resin is preferably a high molecular weight polymer suitable examples of which are polyethylene, polypropylene, ethylene/vinyl acetate copolymers, and ethylene/propylene copolymers. 30

The curative preferably comprises a phenolic resin which may be halogenated. A metal oxide such as zinc oxide may be included with the phenolic resin.

Curing of the polynorbornene phase of the blend during agitation thereof is known as "Dynamic Vulcanisation". Provided that sufficient polyolefin is present in the blend, generally more than 35 parts by weight based on the total weight of polynorbornene and polyolefin, then the resultant products behaves as a thermoplastic but will feature elastic properties and retain good set resistance at room temperature and at elevated temperatures. Thermoplastic elastomer blends according to the invention of low hardness can be obtained by the addition of a softener if desired to relatively high loadings such as could not be accepted by known thermoplastic elastomer blend formulations comprising a rubber and a plastic. 40

The elastomer of the invention may include other ingredients. For example, a thermoplastic elastomer such as a styrene-ethylene-butylene-styrene (SEBS) resin preferably with a corresponding reduction in the amount of polyolefin resin in the blend can be added to produce products of low hardness, but still with good set resistance at low temperatures. Black and non-black fillers and extenders can also be added which may modify the physical properties such as hardness and modulus but without significantly affecting the set resistance. 45

The products are preferably made by blending polynorbornene with molten polyolefin resin in a suitable mixing unit e.g. Banbury mixer, adding required additional product modifiers, e.g. softeners, fillers, pigments, etc. With the blend at a temperature above the melting point of the polyolefin resin, typically 170°C for polypropylene, a curing resin and activator are added, and intimate mixing of the blend continued until cure of the polynorbornene is complete. At this time a suitable antidegradant is preferably added and mixing continued until the antidegradant has been dispersed fully in the blend. The material can be discharged from the mixer and, if desired, sheeted off by passing through a two roll mill. 50

55 The following examples further illustrate the invention:- 55

In the Examples a polynorbornene and a paraffinic oil were first mixed together to form a first stage. The first stage was then mixed with the remaining ingredients except the curative and antidegradant. After blending of the polymers and other ingredients for about seven minutes accompanied by an increase in temperature to from 165-170°C whereat the plastic resins softened and melted the curative was added. Mixing continued for a further ten minutes with the temperature being maintained at 165°C or above. The antidegradant was then added and after mixing for a further two minutes the mixture was discharged and formed into a sheet by passing it through a two roll mill. 60

In the following Table 1 Example 1 is a comparison example in which no phenolic curative was added so that the polynorbornene rubber is unvulcanised. 65

TABLE I

	<u>EXAMPLE</u>	(1)	(2)	(3)	(4)	
5	Polynorbornene <sup>1</sup>	65.00	65.00	65.00	65.00	5
	Paraffinic Oil <sup>2</sup>	<u>130.00</u>	<u>130.00</u>	<u>130.00</u>	<u>130.00</u>	
10	1st Stage	<u>195.00</u>	<u>195.00</u>	<u>195.00</u>	<u>195.00</u>	10
	1st Stage <sup>M/B</sup>	195.00	195.00	195.00	195.00	
15	Polypropylene <sup>3</sup>	35.00	35.00	35.00	35.00	15
	Carbon Black <sup>4</sup>	5.00	5.00	5.00	5.00	
20	Stearic Acid	0.58	0.58	0.58	0.58	20
	Zinc Oxide	2.90	2.90	2.90	2.90	
25	Antidegradants <sup>5</sup>	1.15	1.15	1.15	1.15	25
	Phenolic curing resin <sup>6</sup>	-	9.75	9.75	9.75	
30	Chlorinated <sup>7</sup> Polyethylene	-	-	5.00	5.00	30
	Decabromodiphenyl <sup>8</sup> oxide	-	-	-	5.00	
35	1. Norsorex supplied by CDF Chimie, 2. Enerpar 23 supplied by BP, 3. Propathene GWM22" used, supplied by ICI, 4. Sterling SO" (N550) used, supplied by Cabot Carbon, 5. A blend of Irganox 1010 (Ciba Geigy) and Vulkanox MB2 (Bayer) used in ratio 0.15.1, 6. SP1055 Bromomethyl alkylated phenol-formadehyde resin supplied by Schenectady-Midland, 7. "CM3630" supplied by Bayer, 8. "Saytex 102" supplied by Saytech.					35
40	Injection moulded test plaques, were formed using a melt temperature of 175°C, from the products obtained which were tested. The results are shown in Table II.					40

TABLE II

5	<u>EXAMPLE</u>	(1)	(2)	(3)	(4)	5
	Hardness (Shore A)	52	56	56	57	
	Hardness (IRHD)	56	60	60	62	
10	Modulus @ 100% (MPa)	2.9 (1.3)	2.9 (1.5)	2.6 (1.7)	2.6	10
	Elongation @ Break (%)	330 (580)	150 (280)	130 (180)	150	
15	Tensile Strength (MPa)	3.0 (3.2)	3.0 (2.5)	2.8 (1.9)	2.9	15
20	Compression Set, 22 hrs @ 23°C (%)	82	27	17	20	20
25	Compression Set, 22 hrs @ 70°C (%)	95	40	25	20	25

Stress-Strain values outside parenthesis measured in flow direction, values in parenthesis measured transverse to flow direction.

30 The effect on compression set by the vulcanisation of the polynorbornene rubber is demonstrated by comparison of the properties of the products of Examples 2 to 4 with the product of Example 1. 30

In Table III the effect of high levels of plastic to rubber is shown in Examples 5, 7 and 9. The effect of fillers can be seen in Examples 6 and 7.

TABLE III

EXAMPLE	(5)	(6)	(7)	(8)	(9)	
5 Polynorbornene (Norsorex Powder)	65.00	30.00	65.00	65.00	65.00	5
10 Paraffinic Oil (Enerpar 23)	130.00	45.00	130.00	97.50	130.00	
	195.00	75.00	195.00	162.50	195.00	10
15 1st Stage <sup>M</sup> / <sub>B</sub> Polypropylene	180.00	75.00	195.00	162.50	195.00	15
	40.00	70.00	35.00	35.00	35.00	
Carbon Black	5.00	3.00	5.00	50.00	50.00	
20 Stearic Acid	0.58	-	0.58	0.58	0.58	20
Zinc Oxide	2.70	1.50	2.90	2.90	2.90	
25 Chlorinated Polyethylene	5.00	3.00	5.00	-	5.00	25
Phenolic curing resin (SP1055)	9.00	4.50	9.75	7.80	9.75	
30 Antidegradents	1.15	1.15	1.15	1.15	1.15	30
Calcium Carbonate <sup>9</sup>	-	25.0	-	-	-	
35 Precipitated Silica <sup>10</sup>	-	-	10.0	-	-	35
Decabromodiphenyl oxide	-	-	-	-	5.00	
40 (9. "calmote UF"; supplied by Tarmac Roadstone, 10. "VN3" supplied by ID Chemicals)						40
45 Hardness (Shore A)	62	95	55	70	66	45
Hardness (IRHD)	68	(Shore D-42)	60	75	70	
50 Modulus @ 100% (MPa)	3.3(1.9)	10.4	2.7(1.7)	5.4	3.2	50
Elongation @ Break (%)	140(210)	100(80)	140(260)	180	140	
55 Tensile strength (MPa)	3.6(2.4)	10.4(7.0)	2.9(2.6)	7.1	3.4	55
Compression Set, 22 hrs @ 23°C. (%)	22	-	18	-	-	
60 Compression Set, 22 hrs @ 70°C (%)	28	48	32	40	21	60

In the following Examples 10 to 13 the effect of using different polyolefins is illustrated.

TABLE IV

	(10)	(11)	(12)	(13)	
5					5
Polynorbornene	65.0	65.0	60.0	65.0	
Paraffinic Oil	<u>97.5</u>	<u>97.5</u>	<u>90.0</u>	<u>97.5</u>	
10	<u>162.5</u>	<u>162.5</u>	<u>150.0</u>	<u>162.5</u>	10
Blends of polynorbornene and paraffinic oil mixed as					
1st stage <sup>M</sup> / <sub>B</sub> . This then added to the second stage as					
15	follows:				15
	1st stage <sup>M</sup> / <sub>B</sub>	162.5	162.5	150.0	162.5
20	Polypropylene <sup>1</sup>	35.0	-	20.0	20.0
	Polypropylene <sup>2</sup> copolymer	-	15.0	-	-
25	High density <sup>3</sup> polyethylene	-	20.0	-	-
	Ethylene propylene <sup>4</sup> copolymer	-	-	20.00	-
30	Ethylene Vinyl <sup>5</sup> Acetate copolymer	-	-	-	15.0
	Carbon black <sup>6</sup>	5.0	5.0	5.0	5.0
35	Stearic Acid	0.58	0.58	0.60	0.58
	Zinc Oxide	2.9	2.9	2.4	2.9
	Phenolic curing resin <sup>7</sup>	7.8	7.8	9.0	9.75
40	Chlorinated Polyethylene <sup>8</sup>	5.0	5.0	5.0	5.0
	Antidegradant <sup>9</sup>	0.1	0.1	0.1	0.1
45	1. Polypropylene homopolymer - Propathene GM22 used, supplied by ICI				45
	2. Polypropylene copolymer - Propathene GM101 used, supplied by ICI				
50	3. High density polyethylene - Vestolen A6016 used, supplied by Chemische Werke Huls AG				50
	4. Ethylene-propylene copolymer - Vistalon 719 used, supplied by Esso				
55	5. Ethylene vinyl acetate copolymer - Evatane 18-02 used, supplied by ICI				55
	6. Carbon black - Sterling SO (N550) used, supplied by Cabot Carbon				
60	7. Phenolic curing resin - SP1055 used, supplied by Schenectady-Midland				60
	8. Chlorinated polyethylene - CM3630 used, supplied by Bayer				
65	9. Antidegradant - Irganox 1010 used, supplied by Ciba-Geigy				65

Test plaques were formed from the products of Examples 10 to 13 by injection moulding at a melt temperature of 175°C and the properties measured. The results are shown in Table V.

		TABLE V				
		(10)	(11)	(12)	(13)	
10	Hardness (Shore A)	64	63	55	52	10
	Hardness (IRHD)	70	69	60	56	
15	Modulus @ 100% (MPa)	3.7 (2.6)	3.2 (2.2)	2.9 (1.9)	2.5	15
	Elongation @ Break (%)	130 (230)	140 (270)	170 (320)	140	
20	Tensile Strength (MPa)	3.9 (3.5)	3.5 (3.8)	3.2 (4.0)	2.7	20
25	Compression Set 22 hrs @ 23°C (%)	17	18	18	18	25
	Compression Set 22 hrs @ 70°C (%)	30	28	40	50	
30	Stress-strain values outside parenthesis measured in flow direction, Values inside parenthesis measured transverse to flow direction.					30

The above Examples show that the use of polypropylene high density polyethylene copolymer tends to produce slightly lower hardness products, than when using straight polypropylene homo-polymer with also higher elongation at break and lower modulus figures.

The ethylene-propylene copolymer used in Example II has a very high ethylene content (approx. 77%) and alone can be processed as a thermoplastic. The incorporation of that material improves processability, by increasing the plastic phase level, whilst maintaining a low product hardness. The compression set at elevated temperatures suffers slightly, whilst elongation and tensile strength at break shown some improvement. Ethylene vinyl acetate copolymer used in Example 13, being a much softer, lower softening point material than polypropylene, produces low hardness products, but with rather inferior set resistance at elevated temperatures.

The effect of using a non-halogenated phenolic curing resin is illustrated in the following Example 14. For comparison with a halogenated phenolic resin Example 10 is set out again with Example 14 in the following Table.

TABLE VI

To illustrate the effect of substituting a non-halogenated phenolic resin for a halogenated one, recipe (10) is again listed for reference.

	(10)	(14)	
5 Polynorbornene	65.0	65.0	
5 Paraffinic Oil	97.5	97.5	5
Blends of polynorbornene and paraffinic oil mixed as 1st stage $M/B$			
10 This then added to the second stage as follows:-			10
1st Stage $M/B$	162.5	162.5	
15 Polypropylene	35.0	35.0	15
Carbon Black	5.0	5.0	
20 Stearic Acid	0.58	0.58	20
Zinc Oxide	2.9	2.9	
25 Halogenated phenolic curing resin <sup>1</sup>	7.8	-	25
Non-halogenated phenolic curing resin <sup>2</sup>	-	7.8	
30 Chlorinated Polyethylene	5.0	5.0	30
Antidegradant	0.1	0.1	
1. SP1055—Bromo-methyl alkylated phenol-formaldehyde resin supplied by Schenectady-Midland			
35 2. SP1045—Dimethylol-p-nonyl phenol-resin supplied by Schenectady-Midland			35
(All other ingredients as listed in the original table for recipe (10) through (13). The following properties were measured on the products of Examples 10 and 14 after injection moulding test plaques using a melt temperature of 175°C.			
40			40

TABLE VII

	(10)	(14)	
45 Hardness (Shore A)	64	63	45
Hardness (IRHD)	70	70	
50 Modulus @ 100% (MPa)	3.7 (2.6)	3.6 (2.4)	50
Elongation @ Break (%)	130 (230)	110 (260)	
55 Tensile Strength (MPa)	3.9 (3.5)	3.7 (3.6)	55
60 Compression Set 22 hrs @ 23°C (%)	17	19	60
Compression Set 22 hrs @ 70°C (%)	30	39	

65 Stress-strain values outside parenthesis measured in flow direction Values inside parenthesis

65



measured transverse to flow direction.

The use of a non-halogenated phenolic resin produces slightly lower hardness and modulus values with higher set values at elevated temperatures, indicating a lower state of cure of the polynorbornene phase, than that obtained with the halogenated material. Nevertheless the products thus obtained are still interesting.

The following Examples illustrate the use of a sulphur based cure system.

TABLE VIII

10				10
		(15)	(16)	
15	Polynorbornene <sup>1</sup>	65.0	65.0	15
	Paraffinic Oil <sup>2</sup>	<u>48.75</u>	<u>97.5</u>	
		<u>113.75</u>	<u>162.5</u>	
20	Blends of polynorbornene and paraffinic oil mixed as 1st stage <sup>M</sup> / <sub>B</sub>			20
	This then added to the second stage as follows:			
25	1st Stage <sup>M</sup> / <sub>B</sub>	113.75	162.5	25
	Polypropylene <sup>3</sup>	35.0	35.0	
30	Carbon Black <sup>4</sup>	5.0	5.0	30
	Stearic Acid	0.65	0.65	
35	Zinc Oxide	3.25	3.25	35
	Sulphur	0.325	0.325	
40	4,4'-Dithiodimorpholine <sup>5</sup>	0.975	0.975	40
	Sulphonamide derivative <sup>6</sup>	0.65	0.65	
	Tellurium Diethyldithiocarbamate <sup>7</sup>	0.52	0.52	
45	Dimethyl-diphenyl-thiuram disulphide <sup>8</sup>	0.975	0.975	45
	Antidegradant <sup>9</sup>	0.15	0.15	

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	1.	Norsorex powder	- supplied by Manchem, produced by CDF Chemie	
	2.	Enerpar 23	- supplied by BP Chemicals	
5	3.	Propathene GWM 22	- supplied by ICI	5
	4.	Sterling SO (N550)	- Cabot Carbon	
10	5.	Sulfasan R	- supplied by Monsanto	10
	6.	Vulkalent E/C	- supplied by Bayer	
15	7.	Tellurac	- supplied by Vanderbilt	15
	8.	Vulkalent I	- supplied by Bayer	
	9.	Irganox 1010	- supplied by Ciba-Geigy	

The following properties were measured on the above after injection moulding test plaques using a melt temperature of 175°C.

TABLE IX

5		(15)	(16)	5
	Hardness (Shore A)	76	63	
10	Hardness (IRHD)	80	69	10
	Modulus @ 100% (MPa)	6.3	3.1	
15	Elongation @ Break (%)	210	150	15
	Tensile Strength (MPa)	7.5	3.2	
20	Compression Set 22 hrs @ 70°C (%)	49.0	48.3	20
	Stress-strain values measured in flow direction			

The following Examples illustrate the effect of replacing a portion of the plastic resin (polypropylene) by an "S.E.B.S." type (styrene-ethylene-butylene-styrene) thermoplastic elastomer.

TABLE X

30		(17)	(18)	(19)	30
35	Polynorbornene <sup>1</sup>	65.0	65.0	65.0	35
	Paraffinic Oil <sup>2</sup>	<u>130.0</u>	<u>130.0</u>	<u>130.0</u>	
40	1st stage	<u>195.0</u>	<u>195.0</u>	<u>195.0</u>	40
	1st stage	150.0	150.0	150.0	
45	Polypropylene <sup>3</sup>	40.0	30.0	20.0	45
	SEBS <sup>4</sup>	-	10.0	20.0	
50	Stearic Acid	0.5	0.5	0.5	50
	Zinc Oxide	3.0	3.0	3.0	
55	Chlorinated Polyethylene <sup>5</sup>	5.0	5.0	5.0	55
	Magnesium Oxide	0.5	0.5	0.5	
	Phenolic Curing Resin <sup>6</sup>	7.2	7.2	7.2	
60	Antidegradant <sup>7</sup>	0.1	0.1	0.1	60

Mixing and moulding methods were used as in the previous examples and the following test results obtained:-

65

TABLE XI

	(17)	(18)	(19)	
5				5
Hardness (Shore A)	70	65	51	
Hardness (IRHD)	70	68	53	
10				10
Modulus @ 100% (MPa)	3.6 (1.8)	3.2 (2.0)	1.4 (1.2)	
Elongation @ break (%)	110 (200)	170 (220)	190 (200)	
15				15
Tensile strength (MPa)	3.9 (2.5)	3.8 (2.8)	2.1 (2.2)	
Compression set 22 hrs @ 70°C (%)	41	41	36	
20				20
Examples 17 to 19 show that "SEBS" can be used to replace polypropylene to constitute the plastic phase of the blend and produce low hardness, rubbery products, whilst still retaining good set resistance at elevated temperatures.				
The following examples illustrate the effects of carbon black loadings, as a potential reinforcing filler;				
25				25

TABLE XII

	(20)	(21)	(22)	(23)	
30					30
Polynorbornene	65.0	65.0	65.0	65.0	
Paraffinic Oil	<u>130.0</u>	<u>130.0</u>	<u>130.0</u>	<u>130.0</u>	
35					35
1st stage	195.0	195.0	195.0	195.0	
40					40
1st stage	162.5	162.5	162.5	162.5	
Polypropylene	35.0	35.0	35.0	35.0	
Carbon Black <sup>8</sup>	-	15.0	25.0	40.0	
45					45
Stearic Acid	0.58	0.58	0.58	0.58	
Zinc Oxide	2.9	2.9	2.9	2.9	
50					50
Chlorinated Polyethylene	5.0	5.0	5.0	5.0	
Phenolic Curing Resin	7.8	7.8	7.8	7.8	
55					55
Magnesium Oxide	0.5	0.5	0.5	0.5	
Antidegradant	<u>0.1</u>	<u>0.1</u>	<u>0.1</u>	<u>0.1</u>	

60 The following test results were obtained:-

60

TABLE XIII

	(20)	(21)	(22)	(23)	
5 Hardness (Shore A)	64	66	68	71	5
Hardness (IRHD)	64	71	72	74	
10 Modulus @ 100% (MPa)	3.2(2.5)	4.2(2.6)	3.5(3.0)	-	10
Elongation @ break (%)	100(120)	120(90)	110(120)	90(90)	
Tensile Strength (MPa)	3.2(2.9)	4.4(2.6)	3.8(4.4)	3.6(4.2)	15
15 Compression set 22 hrs @ 70°C (%)	33	33	31	30	

20 Examples 20 to 23 illustrate the effect of increased loadings of carbon black. This material can be used as an 'extender' (cheapener), increasing hardness, modulus, and tensile strength values, while retaining good set resistance at elevated temperatures.  
The following examples show the effects of incorporating a non-black 'filler':-

	(24)	(25)	(26)	(27)	
25					25
30 Polynorbornene	65.0	65.0	65.0	65.0	30
Paraffinic Oil	<u>130.0</u>	<u>130.0</u>	<u>130.0</u>	<u>130.0</u>	
1st stage	<u>195.0</u>	<u>195.0</u>	<u>195.0</u>	<u>195.0</u>	35
35 1st stage	162.5	162.5	162.5	162.5	
40 Polypropylene	35.0	35.0	35.0	35.0	40
Treated Calcined Clay <sup>9</sup>	-	15.0	25.0	40.0	
Stearic Acid	0.58	0.58	0.58	0.58	45
45 Zinc Oxide	2.9	2.9	2.9	2.9	
Chlorinated Polyethylene	5.0	5.0	5.0	5.0	50
50 Phenolic curing resin	7.8	7.8	7.8	7.8	
Magnesium Oxide	0.5	0.5	0.5	0.5	
55 Antidegradant	<u>0.1</u>	<u>0.1</u>	<u>0.1</u>	<u>0.1</u>	55

The following test results were obtained:-

TABLE XV

	(24)	(25)	(26)	(27)	
5 Hardness (Shore A)	64	67	67	72	5
Hardness (IRHD)	64	67	67	74	
10 Modulus @ 100% (MPa)	3.2(2.5)	3.5(2.4)	2.7(2.6)	3.6(2.5)	10
Elongation @ break (%)	100(120)	100(100)	100(130)	150(160)	
Tensile strength (MPa)	3.2(2.9)	3.6(2.5)	3.2(3.0)	4.1(3.0)	
15 Compression set (%) 22 hrs @ 70°C	33	33	33	37	15
20 Examples 24 to 27 show the effect of increased loadings of a non-black 'filler'. This material increases hardness, slightly increases tensile strength, with some slight sacrifice of set resistance at higher loadings.					20
25 Key to the materials of Examples 17 to 27					25
1. Norsorex Powder	- produced by CDF Chemie				
2. Enerpar 23	- supplied by B.P. Chemicals				
30 3. Propathene GWM 22	- supplied by ICI				30
4. Kraton <sup>G</sup> 1651	- supplied by Shell				
35 5. CM 3630	- supplied by Bayer				35
6. SP 1055	- supplied by Schenectady-Midland				
40 7. Irganox 1010	- supplied by Ciba-Geigy				40
8. Sterling SO (N550)	- supplied by Cabot Carbon				
45 9. Translink 37	- supplied by Croxton & Garry				45
In the Examples the test methods used were as follows:					
50 Shore A hardness	.....ASTM D2240				50
IRHD hardness	.....B.S.903 Part A26				
Modulus @ 100%	)				
55 )					55
Elongation @ Break	) .....B.S.903 Part A2				
)					
Tensile Strength	)				
60 Compression Set	.....B.S.903 Part A6				60
	Method A Type 1				
65 CLAIMS					65

1. A thermoplastic elastomer comprising a blend of a polynorbornene and a polyolefin resin, the polynorbornene being cured during blending by the addition of a curative.
2. A thermoplastic elastomer as claimed in Claim 1, wherein the polynorbornene has a molecular weight above 2,000,000.
- 5 3. A thermoplastic elastomer as claimed in Claim 1 or Claim 2, wherein the polyolefin comprises polyethylene, polypropylene, an ethylene/vinyl acetate copolymer or an ethylene/propylene copolymer.
4. A thermoplastic elastomer as claimed in any preceding claim, wherein the curative comprises a phenolic resin.
- 10 5. A thermoplastic elastomer as claimed in Claim 4, wherein the phenolic resin is halogenated.
6. A thermoplastic elastomer as claimed in Claim 4 or Claim 5, wherein the curative also comprises a metal oxide.
7. A thermoplastic elastomer as claimed in any preceding claim, wherein the blend contains more than 35 parts by weight of polyolefin resin based on the total weight of polynorbornene and polyolefin.
- 15 8. A thermoplastic elastomer as claimed in any preceding claim, wherein the blend also includes, a softener, a filler, an extender or mixtures thereof.
9. A thermoplastic elastomer as claimed in any preceding claim, wherein the blend also includes added thermoplastic elastomer.
- 20 10. A thermoplastic elastomer as claimed in Claim 9, wherein the added thermoplastic elastomer comprises a styrene-ethylene-butylene-styrene resin.
11. A process for producing a thermoplastic elastomer blend comprising the steps of mechanically blending a polynorbornene polymer and a polyolefin resin, heating the mixture during blending, adding a curative to the mixture when the mixture is at least substantially molten, and continuing the mechanical blending until the polynorbornene phase in said blend is substantially cured.
- 25 12. A process as claimed in Claim 11, wherein the mixture is heated during blending to at least the melting point of the polyolefin resin.
13. A process as claimed in Claim 11 or Claim 12, wherein an antidegradant is added after the addition of the curative.
- 30 14. A process as claimed in any of Claims 11 to 13, wherein the polynorbornene is mixed with a paraffinic oil before blending with the polyolefin resin.
15. A thermoplastic elastomer substantially as described herein with reference to any one of Examples 2 to 27.
- 35 16. A process for producing a thermoplastic elastomer substantially as described herein with reference to any one of Examples 2 to 27.